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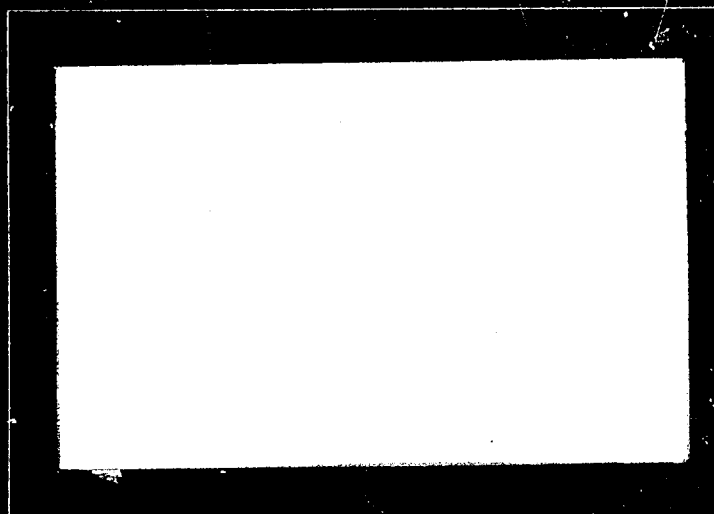
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NAVAL RESEARCH LABORATORY REPORT

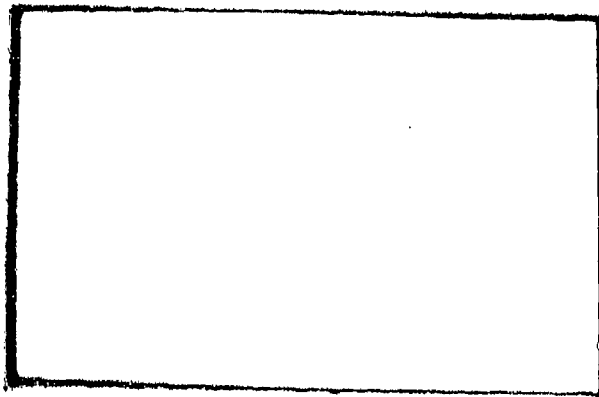
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CHEMISTRY DIVISION - PROTECTIVE CHEMISTRY SECTION

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(6) CHAMBER TESTS WITH HUMAN SUBJECTS
VII. THE EFFECT OF CONCENTRATION
OF H VAPOR AND TIME OF EXPOSURE
ON THE PROTECTION AFFORDED BY
CC-2 IMPREGNATED CLOTHING,

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and J. H. Heinen.

(14) Report P-2528

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NRL Problem P-60

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ABSTRACT

This report describes the results of an investigation to evaluate, by means of chamber tests, the effect of concentration of H vapor and the effect of time of exposure on the protection afforded by 1-1/2 layer CC-2 impregnated clothing.

As a result of this investigation it has been concluded that: (a) within the range of 10-100 GH/l. , the protection is relatively independent of the concentration of agent, and (b) the protection is primarily a function of the time of exposure.

It was indicated that, for successive daily H vapor exposures, men wearing 1-1/2 layer CC-2 impregnated clothing are capable of tolerating a total of 4 to 8 exposure hours, irrespective of agent concentration within the range of 10 to 100 GH/l. This time of exposure may be incurred as a continuous exposure or as intermittent daily exposures of any duration from 1 to 4 hours.

It was also indicated that under the most adverse conditions studied in these series of tests (i.e.; low concentration of H vapor and long time of exposure), a CT of approximately 3000 is the upper limit for which 1-1/2 layer CC-2 clothing may be expected to provide adequate protection.

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INTRODUCTION

A. Authorization

1. This work was authorized under Project 547/41, "Maintenance, Bureau of Ships", dated 16 December, 1940. The problems which were proposed for study were given in Bureau of Ships Letter S-S77-2(Dz), Serial 811 of 17 December, 1940.

B. Statement of Problem

2. The purpose of this investigation was to determine the effect of (a) variation in H vapor concentration and (b) variation in time of exposure on the protection afforded by 1-1/2 layer CC-2 impregnated clothing.

C. Known Facts Bearing on Problem and Theoretical Considerations

3. Work at this Laboratory and by other investigators has demonstrated that the degree of skin damage incurred by unclothed human subjects (or subjects dressed in plain clothing) on exposure to vesicant vapors is a function of both the concentration of vapor and the time of exposure. Therefore the CT value (concentration in mg./m.³ or %/l x time in min.) is used as a means of combining these two factors in any evaluation of the physiological effects of vesicant vapor exposures.

4. It has been demonstrated further that over a relatively wide range of both time and concentration of vapor, for exposures of unprotected subjects, C and T are inversely proportional ($CT \sim k$); i.e., the same degree of damage is produced by a short exposure to a high vapor concentration as is produced by a long exposure to a low vapor concentration.

5. At this Laboratory, in the evaluation of CC-2 impregnated clothing as a means of protection against the effects of exposure to H vapor, evidence has been obtained indicating that, in the case of subjects wearing CC-2 impregnated protective clothing, C and T are not inversely proportional ($CT \neq k$). This evidence was obtained primarily in chemical tests in which it was found that the total leakage of H vapor through CC-2 impregnated clothing is not a direct function of the concentration of H vapor to which the cloth is exposed. It is planned to describe these and other chemical tests in detail in a separate report, but the data are also briefly summarized in this report.

6. Preliminary physiological evidence that CT is not a constant in the exposure of subjects wearing CC-2 clothing was obtained in the series of chamber tests conducted at this Laboratory and reported in NRL Report No. P-2208 "Chamber Tests with Human Subjects - Part II, Initial Tests of Navy Issue Protective Clothing against H Vapor" dated 22 December, 1943. In this series, subjects clothed in CC-2 impregnated clothing were subjected to 60 minute exposures at CTs ranging from 200 to 2600 (3.3 to 43 %H/l.). The exposures at the higher concentra-

tions produced only very slightly more severe reactions.

7. Subsequently, the CWS at Edgewood Arsenal has reported the results of a similar series of tests in which men dressed in standard Army CC-2 impregnated clothing were subjected to single exposures to H vapor at various CTs from 3,000 to 11,000. No significant difference in effects was observed.

8. As the result of these preliminary observations, it was considered desirable to initiate an investigation to evaluate completely the effect of concentration of H vapor and the effect of time of exposure on the protection afforded by 1-1/2 layer CC-2 impregnated clothing.

D. Previous Work Done at this Laboratory.

9. No previous chamber tests have been conducted at this Laboratory with the primary purpose of evaluating the two effects studied in this series of tests. This report is the 7th of a series on "Chamber Tests with Human Subjects" in which the results obtained in the evaluation of various protective devices against the vesicant effects of persistent chemical warfare agents are reported.

EXPERIMENTAL

10. The chamber tests described in this report were conducted in the NRL chamber according to the general procedure described in NRL Report No. P-2208 "Chamber Tests with Human Subjects, Parts I and II".

11. In all tests each subject was provided with the following 1-1/2 layer protective equipment:

- (a) Standard Navy Issue Arnsen suit impregnated with CC-2 by the water suspension process.
- (b) CC-2 impregnated rib-knit shorts.
- (c) CC-2 impregnated wool gloves.
- (d) 2 pair of CC-2 impregnated cotton socks.
- (e) Arctics.
- (f) Mark IV gas masks.
- (g) S-330 Protective Ointment for the neck and around the facepiece of the mask.

A. Effect of Concentration of H Vapor

12. Groups of 5 - 10 men dressed in the protective equipment described above were subjected to successive daily exposures to H vapor in the chamber. Each exposure was conducted for exactly 60 minutes at 90°F and 65% RH. The clothing was worn for four hours after each exposure. A subject was withdrawn from the test when he incurred an intense erythema (E) on

any part of the body 24 hours after the last exposure (i.e., a "man break").

13. Nine groups of subjects were used. Each group was exposed at a given H vapor concentration, varying from 5 x H/l. to 100 x H/l. (300 to 6000 CT).

14. The results obtained are summarized in Table I. Physiological data are given in Appendix II.

Table I.

EFFECT OF CONCENTRATION OF H VAPOR ON STANDARD
"MAN BREAKS"

1-1/2 layer CC-2 clothing; 60 min. exposure; 90°F and 65% RH.

<u>Date</u>	<u>No. of</u>	<u>Conc. of H</u>	<u>CT of</u>	<u>No. of Exp.</u>	<u>Total CT</u>	<u>Remarks</u>
<u>Started</u>	<u>Subjects</u>	<u>Vapor (x/l.)</u>	<u>Exp.</u>	<u>Tolerated</u>	<u>Tolerated</u>	
4-11-45	10	5.0	300	11.1	3,330	
3- 2-45	8	10.0	600	5.3	3,180	
Various	114	20.0	1200	4.5+	5,400+	21 men not "broken"
11-14-44	7	33.3	2000	4.2	8,400	
3 -12-45	6	40.0	2400	4.5	10,800	
11-28-44	8	50.0	3000	3.6+	10,800+	1 man not "broken"
2 -13-45	5	66.7	4000	3.8	15,200	
2 -20-45	8	83.3	5000	4.5+	22,500+	2 men not "broken"
3 -5- 45	10	100	6000	4.8	28,800	

15. The data in Table I are shown graphically in Plate 1. These data and graphs demonstrate clearly that, for exposure of subjects wearing 1-1/2 layer CC-2 impregnated protective clothing, CT is not a constant as regards the effects produced. Instead, it is shown that in the range of 10 to 100 x H/l. the protection afforded by the CC-2 clothing is relatively independent of concentration of H vapor. If C and T were inversely proportional, as is the case of exposure of unprotected men, a constant value for total CT tolerated would have been obtained for all groups, and the number of exposures tolerated would have decreased progressively as the CT per exposure increased.

16. The greater number (11.1) of exposures tolerated at CT 300 is understandable and not unexpected. The curve shown in Plate 1A should theoretically approach the vertical axis asymptotically since at CT=0 an infinite number of exposures should be tolerated. This test shows that the inflection point lies between CT300 and 600.

17. It has been demonstrated previously that subjects wearing

plain dungaree clothing with CC-2 impregnated shorts receive an intense erythema over the unprotected areas of the body on one exposure at CT 300 (T= 60 min.) Thus, it is indicated that CT 300 may be considered the minimum CT for which 1 or 1-1/2 layer protection is necessary to prevent severe damage as the result of one exposure. This test at CT 300 gives a measure of the protection afforded by 1-1/2 layer CC-2 clothing at the lowest CT for which protection is required.

18. The results obtained in this series of tests confirm those previously obtained in a series of chemical tests. In these chemical tests, the leakage of H vapor through standard suspension process CC-2 impregnated clothing at various H vapor concentrations was measured.

19. One side of a number of 3 in. diameter discs of cloth was exposed at 90°F to an air stream containing definite concentrations of H vapor. The air stream had a flow-rate of 0.5 liters/min., and the exposure was conducted for one hour. During the exposure another air stream, humidified at 65% RH, was passed over the other side of the cloth at 0.2 liters/min. This air stream collected any H vapor which passed through the cloth and carried it into a modified Northrop titrimeter, where analyses for H content were made every five minutes for one hour.

20. The data obtained in this series of tests are presented in Table II.

TABLE II

EFFECT OF CONCENTRATION OF H VAPOR ON "LEAKAGE"
THROUGH CC-2 IMPREGNATED CLOTHING - CHEMICAL TESTS

Standard CC-2 cloth; 60 min. exposure; 90°F and 65% RH.

<u>Conc. of H Vapor</u> <u>(g/l.)</u>	<u>CT of</u> <u>Exposure</u>	<u>Total Leakage for</u> <u>60 Min. Exp. (gH)</u>
10.0	600	13
25.0	1500	23
45.0	2700	34
65.0	3900	53
95.0	5700	33
135.0	8100	28

21. It may be seen from the above results that for 60 minute exposures within the range studied the leakage of H vapor through the impregnated cloth is relatively independent of the concentration of H vapor to which the cloth is exposed. The data are plotted in Plate 2 together with curve A previously shown in Plate 1. A comparison of the two curves shows that there is a good relationship between chemical leakage and number of chamber exposures tolerated; e.g. at CTs 3000-5000

the greatest chemical leakage is observed, and, in this range of CTs, fewer chamber exposures are tolerated than at higher or lower CTs.

22. It was concluded on the basis of both chemical and chamber tests that within the range of 10 to 100 μ H/l. the protection against H vapor afforded by CC-2 impregnated protective clothing is not primarily a function of the concentration of H vapor to which it is exposed. It was indicated that the controlling factor is the time of exposure.

B. Effect of Time of Exposure

23. Groups of 4 - 8 men, dressed as previously described in 1-1/2 layer CC-2 protective clothing, were exposed to H vapor in the chamber at 90°F and 65% RH under the conditions as indicated in Table III.

TABLE III

EXPERIMENTAL CONDITIONS FOR TIME OF EXPOSURE TESTS

<u>Group No.</u>	<u>No. of Men.</u>	<u>Conc. of H Vapor (μ/l.)</u>	<u>Time of Exposure (Min.)</u>	<u>C.T. of Exposure</u>	<u>Type of Test</u>
1	8	10	60	600	Man Break
2	5	10	120	1200	" "
3	7	10	240	2400	1 Exp. only
4	114	20	60	1200	Man Break
5	6	20	120	2400	" "
6	7	20	240	4800	1 Exp. only
7	6	40	60	2400	Man Break
8	4	40	120	4800	" "
9	7	40	240	9600	1 Exp. only

24. "Man break" tests, i.e. successive daily exposures until an intense erythema (E) was incurred, were conducted at 10, 20 and 40 μ H/l., with exposure times of 60 and 120 minutes at each concentration. In addition single 240 minute exposures were conducted at 10, 20 and 40 μ H/l.

25. The results obtained in this series of tests are summarized in Table IV- Physiological data are given in Appendix III.

TABLE IV

EFFECT OF TIME OF EXPOSURE ON STANDARD "MAN BREAKS"

1-1/2 layer CC-2 clothing; 90°F and 65% RH.

Date Started	No. of Subjs.	Conc. of H Vapor (% l.)	Time of Exp. (Min.)	CT of Exp. Exp. Tolerated	No. of Exp. Tolerated	Total Exp. Hours Tolerated	Remarks
3- 2-45	8	10	60	600	5.3	5.3	
3- 2-45	5	10	120	1200	5.6	11.2	
3- 1-45	7	10	240	2400	1.7 (est)*	6.8*	5 men not "broken"
Various	114	20	60	1200	4.5+	4.5+	21 men not "broken"
3-12-45	6	20	120	2400	3.5	7.0	
3-11-45	7	20	240	4800	1.6(est.)*	6.4*	4 men not "broken"
3-12-45	6	40	60	2400	4.5	4.5	
3-12-45	4	40	120	4800	4.0	8.0	
3-17-45	7	40	240	9600	2.5+(est)*	8.0+*	7 men not "broken"

Since the men in these tests were subjected to only one exposure, the number of exposures tolerated was estimated by assuming that all the subjects who did not "break" as a result of the single exposure but had incurred a moderate erythema (E) would have "broken" on a second exposure. In view of the results obtained and the magnitude of the reactions exhibited by these subjects (Appendix II), it is believed that this is a valid assumption and that the estimated values are significant.

26. The data in Table IV are shown graphically in Plate 3. Inspection of these data shows again that, for exposure of subjects wearing CC-2 impregnated protective clothing, CT is not a constant. Instead it is demonstrated that within the range of conditions studied, the protection afforded by this type of clothing is primarily a function of the time of exposure and is almost entirely unaffected by the concentration of agent.

27. From this series of tests it is indicated that, for successive daily H vapor exposures, men wearing 1-1/2 layer CC-2 protective clothing are able to tolerate a total of approximately 4 - 8 exposure hours. This time of exposure may be incurred as a continuous exposure or as intermittent daily exposures of any duration from one to four hours.

SUMMARY AND CONCLUSIONS

1. Standard "man break" tests have been conducted to determine the effect of time of exposure and concentration of agent on the protection afforded by 1-1/2 layer CC-2 impregnated clothing.
2. These tests have demonstrated that (a) the protection is relatively independent of the concentration of agent, and (b) the protection is primarily a function of the time of exposure.
3. In "man break" tests at various CT values from 600 to 6000 (10 to 100 μ H/l. for 60 min.) the average number of exposures tolerated ranged from 3.6+ to 5.3. The average total CT tolerated ranged from 3,000 to 30,000. These data showed that the effects of concentration and time are not inversely proportional (CT \propto k) for subjects wearing CC-2 impregnated protective clothing. It was indicated that the protection provided is a function of time of exposure, not concentration of agent.
4. Chemical tests also furnished evidence supporting this conclusion. Within the range of 10 to 135 μ H/l. the leakage of H vapor through CC-2 impregnated clothing is almost entirely independent of the concentration of H vapor to which the cloth is exposed.
5. It was observed that slightly greater chemical leakage occurred at CTs 3000-5000 (50 to 80 μ H/l. for 60 min.). Also in this range of CTs slightly fewer chamber exposures were tolerated than were tolerated at higher or lower CTs within the range of 600 to 6000.
6. "Man break" tests at 10, 20 and 40 μ H/l. with exposure times of 60 and 120 minutes at each concentration, and single 240 minute exposures at these concentrations also have shown that CT is not a constant for subjects wearing CC-2 impregnated clothing, but that time of exposure is the controlling factor in the protection provided. It was indicated that, for successive daily H vapor exposures, men wearing 1-1/2 layer CC-2 protective clothing are capable of tolerating a total of 4 to 8 exposure hours. This time of exposure may be incurred as a continuous exposure or as intermittent daily exposures of any duration from 1 to 4 hours.
7. It is indicated that under the most adverse conditions studied in these series of tests (i.e. low concentration of H vapor and long time of exposure), a CT of approximately 3000 is the upper limit for which 1-1/2 layer CC-2 clothing may be expected to provide adequate protection.

RECOMMENDATIONS

1. It is recommended that in the evaluation of the protection afforded by CC-2 impregnated clothing, more emphasis be placed

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on the length of time during which protection is provided (i.e. time of exposure) than on the concentration of agent or CT of exposure.

2. It is recommended that an effort be made to increase protection provided by CC-2 impregnated clothing under adverse conditions of exposure, i.e., low concentrations of H vapor for long periods of time.

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The following people have participated in conducting the experimental work involved in the tests described in this report.

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N. M. Clausen, Lt.(jg) (MC) USNR - Assistant Medical Officer
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J. B. Leary, PhM 2/c -) and Preparation of Subjects
B. Winter, PhM 3/c -) for Chamber.
G. R. Butler, Y 2/c - Secretarial
C. F. Adams, Cox - Volunteer Personnel

Technical Group

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H. W. Fox - Protective Clothing Supply
G. M. Gantz - Protective Clothing Supply
L. I. Jussila - Chemical Leakage Tests
F. C. Thiele, CSP(X) - Preparation of H (TQ)
A. M. Thomson - Protective Clothing Analysis

The subjects participating in these tests were volunteer personnel from NTC, Bainbridge, Maryland.

APPENDIX I

TABLE V

PHYSIOLOGICAL READINGS - LEGEND

<u>Symbol</u>	<u>Reaction</u>
E•	Moderate Erythema
E	Intense Erythema
E+	Papular Erythema
NPV	Numerous Pin-Point Vesicles
NV	Numerous Vesicles
V	Vesicle
P _m	Moderate Pigmentation
P _s	Intense Pigmentation

Table VI

BODY AREAS - LEGEND

Abbreviation

Area

aaf	anterior axillary folds
aar	anterior arms
ab	abdomen
ale	anterior legs
ar	arms
ash	anterior shoulders
athi	anterior thighs
ax	axillae
bt	buttocks
C ₇	7th cervical
cf	cubital fossa
cl	clavicle
dh	dorsum of hands
dth	dorsal thorax
el	elbows
fa	forearms
igr	intergluteal folds
il	iliac crest
ing	inguinal
kn	knees
le	legs
lth	lateral thorax
lum	lumbar
par	posterior axillary folds
par	posterior arms
pen	penis
ple	posterior legs
pop	popliteal spaces
psh	posterior shoulders
pthi	posterior thighs
sc	scapulae
scr	scrotum
umar	upper medial arm
vth	ventral thorax
wr	wrist

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APPENDIX II

DETAILED PHYSIOLOGICAL DATA FOR TESTS ON EFFECT

OF CONCENTRATION OF AGENT

Table VII

TEST NO. 1 - "MAN BREAK" AT CT 300 (T = 60 Min.)

Date Started: 4-11-45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
13	E psh, sc, dth, pop E• umar, athi, kn, ale, paf, pthi, ple	E umar, aar, cf, athi, kn, ale, paf, psh, par, sc, dth, pthi, pop, ple
9	E pop E• athi, kn, ale, paf, psh, sc, dth, pthi, ple	E pop E• athi, kn, ale, paf, psh, sc, dth, pthi, ple
9	E pop E• athi, kn, ale, pthi, ple	E pop E• athi, kn, ale, pthi, ple
11	E pop E• psh, sc, dth	E pop E• kn, ale, psh, sc, dth, pthi, ple
14	E pop	E pop E• athi, kn, ale, psh, sc, dth, pthi, ple
8	E pop E• paf, par, sc, pthi, ple, psh	E pop, paf E• athi, kn, ale, par, pthi, ple
13	E pop E• umar, cf, paf, pthi, ple	E pthi, pop, ple E• umar, kn, ale, paf, psh, par, sc, dth
7	E kn, ale, par, pop E• aar, athi	E aar, athi, kn, ale, par, pthi, pop, ple
14	E pop E• athi, ale, psh, sc, dth, pthi, ple	E kn, sc, dth, pop E• athi, ale, psh, pthi, ple
14	E pop E• athi, kn, ale, psh, pthi, ple	E pop E• athi, kn, ale, psh, pthi, ple, sc, dth

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Table VIII

TEST NO. 2 - "MAN BREAK" at CT 600 (T = 60 Min.)

Date Started: 3-2-45

No. of Exposures Tolerated	Readings (Hours After Last Exposure)	
	24	48
6	E psh, sc, dth, paf, lth, aaf, umar E° aar, cf, pop	E sc, dth, paf, umar, aar, cf, athi, kn, pop E° psh, par, el
6	E athi, paf, psh, sc, dth, pop E° ash, aar, cf, ax, lth, kn, ale, pthi, ple	E paf, pah, sc, dth, pthi, pop, ple, ax, lth, umar, aar E° ash, cf, aaf, kn
5	E psh, sc E° ash, dth	E psh, sc, dth E° ash, aaf, athi, kn, ale
4	E cl, ash, aar, umar, cf, athi, kn, paf, psh, sc, pop E° fa, lth, vth, par, C ₇ , dth, pthi	E+ athi, kn, pthi, pop E° ash, aar, aaf, paf, psh, sc E° dth
6	E ash, cf, paf, psh, sc, dth E° aar, el	P ₈ paf, psh, sc P ₈ ash, aar, cf, aaf, ax, lth, athi, kn, ale, el, dth
4	E cf, paf, psh E° ash, umar, aar, ax, lth, athi, kn, sc, dth, pop	E umar, cf, athi, kn, paf, psh, sc, dth, E° ash, aar, lth, pop
6	E pop E° ash, cf, kn, paf, psh, sc, dth, pthi, ple	E psh, sc, dth, pthi, pop, ple E° el, cf, aaf, kn, ale
5	E lth, paf, psh, sc E° dth, pop	E ax, lth, paf, psh, sc, dth E° umar, pop

Av. 5.3

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TABLE IX

TEST NO. 3 - "MAN BREAK" at CT 1200 (T = 60 Min.)

This test represents the standard exposure conditions used in connection with chamber tests at this Laboratory. Consequently "man break" tests under these conditions have been conducted with a large number of subjects (114) during the past 18 months. The complete physiological data on these subjects will be given in a later report.

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TABLE X

TEST NO. 4 - "MAN BREAK" at CT 2000 (T = 60 Min.)

Date Started: 11-14-44

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
3	'E ax,psh,sc,dth 'E ash,aaf,par,pop	E ash,aaf,aar,thi,kn,psh,sc, dth,paf,pop,ax E cf,ple
3	'E ax,psh 'E sc,dth,pthi,pop	E ax E ash,cf,athi,kn,psh,sc,paf
3	'E psh,sc 'E ax,lth,dth,pop	E+ pop E ax,psh,sc,paf E ash,thi,kn,cf,dth
7	'E ax,cf,dth 'E psh,sc,pop	E kn,ax E thi,le,sc,dth,pop
3	'E psh,sc,dth,pop 'E par,pthi,le	E ash,ar,cf,ax,par,paf,sc, dth,pop E aaf,ar,pthi,le
3	'E ash,ax,lth,psh,sc, dth,pthi,pop,ple 'E cf,athi,kn,ale, par	E ash,aaf,aar,ax,thi,kn,le, psh,paf,sc,dth,pop,par E cf
7	'E ax,sc,pop 'E cf,psh,dth,pthi, ple	E cf,ax,pop E psh,sc,dth

Av. 4.2

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TABLE XI

TEST NO. 5 - "MAN BREAK" at CT 2400 (T - 60 Min.)

Date Started: 3-12-45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
3	E psh,sc,dth E pthi,pop,ple	E ash,cf,psh,sc,dth E cl,umar,aar,lth,athi,kn,ale, pthi,pop,ple
5	E cf,ax,psh,sc,dth pop E ash,aar,lth,kn, par,cl,pthi,ple	E cf,ax,psh,sc,dth E ash,aar,lth,athi,kn,ale,pop, ple
5	E paf,psh E aaf,ax,sc,dth	E ax,paf,psh E cl,ash,aar,cf,aaf,lth,sc,dth
4	E ash,psh,sc,pop E cf,ax,lth,athi, kn,ale,paf,dth, pthi	E ash,umar,aar,cf,lth,athi,kn, ale,psh,sc,pthi,pop E dth
6	E kn,ale,paf,pop E ash,aar,cf,ax, athi,psh,sc,dth, pthi,ple	E athi,kn,ale,psh,sc,dth,pthi, pop,ple E aaf,paf
4	E psh,sc,dth E ash,cf,ax,lth, paf,el	E umar,lth,paf,psh,sc,dth E ash,aar,cf

Av. 4.5

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TABLE XII

TEST NO. 6 - "MAN BREAK" at CT 3000 (T = 60 Min.)

Date Started: 11-28-44

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
2	E psh,paf E° sc,dth	E cf,psh,paf E° sc,dth
5	E cf, pop	E cf,pop E° ax,psh,pthi
2	E psh E° sc,dth	E psh,paf E° sc,dth
4	E ol,ax,paf,cf E° psh,sc,dth,paf	E cf,ax,ar E° ash,athi,kn
2	E psh,sc E° dth,paf	E psh E° paf,sc,dth
6	E cf,pop,pthi E° ax,psh,pop	E cf,athi,le,psh,sc,pop E° ax,dth,par
6+	E° cf,pop,pthi,psh, sc,dth	E° None P ₂ psh,sc,dth,paf,pop
2	E psh,sc E° dth,paf	E° psh,dth,sc,paf

Av. 3.6+

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TABLE XIII

TEST NO. 7 - "MAN BREAK" at CT 4000 (T- 60 Min.)

Date Started: 2-13-45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
5	E psh,sc E ash,cf,athi,kn, pthi,pop,ple	E psh,sc E ax,athi,kn,par,el,pthi, pop,ple
3	E psh,sc,dth E ash,dh,wr,ax, lth,athi,kn	E paf,psh,sc,dth E ash,aar,cf,aaf,ax,lth,athi, kn,el,bt,pthi,pop,ple
3	E psh,sc,pop E ash,aar,cf,aaf, athi,kn,dth, pthi,ple	E ash,aaf,athi,kn,paf,psh,el, sc E aar,cf,ax,lth,dth,pthi,pop, ple
3	E paf,psh,sc,dth E ash,aar,cf,aaf, athi,kn,pthi, pop	E cf,paf,psh,sc,dth E ash,aar,aaf,lth,athi,kn,el, C ₇ bt,pthi,pop,ple
5	E cf E ash,aaf,psh,par, C ₇ ,sc,dth,pthi, pop,ple	E cf,aaf,paf,pop E aar,athi,kn,psh,par,el,sc, bt,pthi,ple

Av. 3.6

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TABLE XIV

TEST NO. 8 - "MAN BREAK" at GT 5000 (T = 80 Min.)

Date Started: 2-20-45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
5	E ash,aar,cf,aaf, ax,athi,kn,paf, psh,sc,dth,pthi, pop E* umar, C ₇	E ash,aar,cf,athi,kn,ale, paf,psh,sc,dth,pthi,pop,ple
5	E psh,sc,dth E* paf,pthi,pop, ple	E psh,sc,dth E* athi,kn,ale,pthi,pop
5+	E* cf,pop	E cf,pop E* aaf,athi,kn,ale,paf,psh, sc,dth,pthi,ple
5	E athi,kn,paf, psh,sc E* umar,cf,ale, par,el,dth, pthi,pop,ple	E umar,aar,cf,athi,kn,ale, paf,psh,sc,dth,pthi,pop, ple E* ash,par,el
3	E psh,sc,dth E* cl,athi,kn,ale, par,el,C ₇ ,pthi	E psh,sc,dth E* cl,ash,aar,cf,aaf,ple,athi, kn,ale,par,el, C ₇ ,pthi,pop
5+	E* ash,paf,psh, sc,dth	E* ash,paf,psh,sc,dth
5	E athi,kn,ale,paf, psh,sc,dth,pthi, pop,ple E* cl	E cf,athi,kn,ale,paf,psh,sc, dth,pthi,pop,ple E* cl,ash,aar,dh,wr,aaf
3	E psh,sc,dth E* athi,kn,paf	E paf,psh,sc,dth E* ash,aaf,athi,kn,ale,pthi, pop,ple

Av. 4.5+

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TABLE XV

TEST NO. 9 - "MAN BREAK" at CT 6000 (T= 60 Min.)

Date Started: 3-5-46

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
6	'E paf,psh,sc,dth 'E ash,umar,aar,cf, lth,athi,kn,pthi, pop,ple	'E ash,umar,cf,lth,athi, kn,ale,psh,sc,dth,pthi, pop 'E el,ple
3	'E psh,sc,dth 'E C ₇	'E paf,psh,sc,dth 'E ash,aaf,lth,vth
3	'E psh,sc,dth	'E ash,psh,sc,dth 'E cf
5	'E paf,psh,sc,dth,pop 'E C ₇ ,pthi	'E+ pop 'E athi,kn,paf,psh,sc,dth, pthi,ple 'E cf,ale
5	'E athi,pop 'E cl,ash,lth,kn, ale,paf,psh,C ₇ sc,dth,pthi,ple	'E+ pop 'E lth,athi,kn,ale,paf,psh, sc,dth,pthi,ple 'E cl,cf,C ₇
5	'E psh,sc,dth,pop 'E ax,lth	'E ax,paf,psh,sc,dth 'E ash,cf,athi,kn,ale,pthi, pop,ple
6	'E umar,athi,kn,paf, psh,sc,pop 'E ash,aar,cf,ale, C ₇ ,dth,pthi,ple	'E ash,umar,cf,aaf,kn,paf,psh, sc,pop 'E lth,athi,ale,el,dth, pthi,ple
4	'E paf,psh,sc,dth, igf 'E cf,athi,kn,el	'E ash,paf,psh,sc,dth 'E cf,ax,athi,kn
5	'E ash,cf,paf,psh, sc,dth 'E umar,aar,ax,lth, athi,kn,ale,el, pthi,pop,ple	'E ash,umar,aar,cf,aaf,lth, vth,athi,kn,ale,paf,psh, sc,dth,pthi,pop,ple 'E el
6	'E paf,psh,sc,dth, pop 'E umar,athi,kn, pthi,ple	'E psh,sc,dth 'E umar,ax,paf,pop

Av. 4.8

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TABLE XVI

EFFECT OF CONCENTRATION OF AGENT - BREAKS/DAY

Date Started	No. of Men	Conc. H (/l.)	H of Exp.	No. of Men Broken On Day No.														Av. Exp. Tolerated	No. of Breaks	Total CT Tolerated
				1	2	3	4	5	6	7	8	9	10	11	12	13	14			
4-11-45	10	5.0	300					1	2	1	1		2	3			11.1	10	3,330	
3-2-45	8	10.0	600				2	2	4								5.3	8	3,180	
Various	114	20.0	1200	8	27	23	20	6	4	3	1	1					4.5	93	5,400	
11-14-44	7	33.3	2000				5		2								4.2	7	8,400	
3-12-45	6	40.0	2400				1	2	2	1							4.5	6	10,300	
11-28-44	8	50.0	3000	4		1	1	1	1	1	*						3.6	7	10,300	
2-13-45	5	66.7	4000			3		2									3.8	5	15,200	
2-20-45	8	83.3	5000			2		4.2*									4.5	6	22,500	
3-5-45	10	100	6000			2	1	4	3								4.8	10	28,800	

* Not "broken"

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APPENDIX III

DETAILED PHYSIOLOGICAL DATA FOR TESTS ON EFFECT OF TIME OF EXPOSURE

TABLE XVII

TEST NO. 10 - "MAN BREAK" at CT 600 (10.0 WH/1. for 60 Min.)

Date Started: 3-2-45

This test is the same test as reported in Appendix II, Test No. 2.

TABLE XVIII

TEST NO. 11 - "MAN BREAK" at CT 1200 (10.0 WH/1. for 120 Min.)

Date Started: 3-2-45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
7	E pop E umar, athi, kn, ale, paf, psh, so, dth, pthi, ple	E umar, aar, aaf, athi, kn, ale, paf, so, dth, pthi, pop, ple, psh
4	E paf, psh, so E ash, umar, aar, of, lth, athi, kn, ale, dth, pthi, pop, ple	E umar, lth, paf, psh, so E ash, aar, athi, kn, ale, dth, pthi, pop, ple
7	NV psh, NPV ash, aaf, so E ash, umar, aar, of, aaf, ax, lth, athi, kn, ale, paf, psh, so, dth E cl, pthi, pop, ple	NV psh, ash, so E cl, ash, umar, aar, of, aaf, ax, lth, athi, kn, ale, paf, psh, par, el, C ₇ , so, dth, pthi, pop, ple
3	E athi, kn, ale, psh, par, so, pthi, pop, ple E umar, aar, of, dh, wr, aaf, paf, el, dth	E umar, aar, of, aaf, lth, athi, kn, ale, psh, par, el, so, dth, pthi, pop, ple E ax
7	E umar, psh E lth, paf, el, so, dth, pop	E umar, paf, pop E psh, so

Av. 5.6

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TABLE XIX

TEST NO. 12 - SINGLE EXPOSURE AT CT 2400 (10.0 H/l. for 240 Min.)

Date Started: 3-1-45

No. of Exposures Tolerated	Readings (Hours after Exposure)	
	24	48
1	E psh,el,so E° scr,paf,C ₇ ,dth	E psh,so,dth E° kn,paf,C ₇
2 *	E° paf,psh,so,dth	E psh,so,dth E° cf,paf
2 *	E° scr	E° paf,pthi
1	E paf,psh,par,el, so,dth E° umar	E psh,par,so,dth,lum E° paf,el
2 *	E° psh,par,el,so, dth,bt,pthi, pop	E° cl,athi,kn,ale,paf,psh, so,dth
2 *	E° psh,so,dth	E° paf,psh,so,dth
2 *	E° paf,psh,so,dth pop	E° paf,psh,so,dth

Av. 1.7

* Since the men in this test were subjected to only one exposure, the number of exposures tolerated was estimated by assuming that all the subjects who did not "break" as a result of the exposure but had incurred an E° would have broken on a second exposure.

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TABLE XX

TEST NO. 13 - "MAN BREAK" at CT 1200 (20.0 WH/1. for 60 Min.)

This test is the same test discussed in Appendix II, Test No. 3.

TABLE XXI

TEST NO. 14 - "MAN BREAK" at CT 2400 (20.0 WH/1. for 120 Min.)

Date Started: 3-12-45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
3	'E paf, psh, sc, dth 'E umar, of, ax, lth	'E umar, ax, paf, psh, sc, dth 'E ash, of, athi, kn, ale, pthi, pop, ple
4	'E ash, aar, of, ax, lth, athi, kn, ale, psh, par, el, sc, dth, pthi, pop, ple 'E vth	'E ash, aar, of, ax, lth, vth, athi, kn, ale, psh, par, el, sc, dth, pthi, pop, ple
4	'E aaf 'E ash, umar, ax, lth, kn, paf, psh, sc, dth, pthi, pop, ple	'E umar, of, aaf, paf, psh, sc, dth, pthi, pop, ple 'E ash, aar, lth, athi, kn, ale
3	'E paf, psh, sc, dth 'E cl, ash, umar, aar, of, ax, lth, kn, C ₇	'E ax, lth, paf, psh, sc, dth, pop 'E ash, of, athi, kn, ale
4	'E ash, aaf, ax, paf, psh, sc, dth 'E cl, aar, of, lth, athi, kn, ale, el, C ₇	'E ash, umar, aar, of, aaf, lth, athi, kn, paf, psh, sc 'E par, el, C ₇ , dth, pthi, pop, ple
3	'E ash, psh, sc, dth 'E of, athi, kn, ale, el	'E ash, of, psh, sc, dth 'E aar, ax, lth, athi, kn, ale, pthi, pop, ple

Av. 3.5

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TABLE XXII

TEST NO. 15 - SINGLE EXPOSURE AT CT 4800 (20.0 H/l. for 240 Min.)

Date Started: 3-11-45

No. of Exposures Tolerated	Readings (Hours After Exposure)	
	24	48
1	E of, athi, kn, el, so, dth, E* ash, aar, ale, paf, psh, pthi, pop, ple	E of, fa, athi, kn, ale, paf, psh, el, so, dth, pthi, pop, ple E* ash, umar, aar, lth
2 *	E* umar, kn, ale, paf, psh, so, dth, pthi, pop	E* umar, psh, so, dth
1	E of, paf, psh, el E* el, umar, athi, kn, so, dth, pop	E of, athi, kn, paf, psh, par, el, so, dth, pthi, pop, ple E* aar, ale
2 *	E* paf, psh, so, dth	E* ax, paf, psh, so, dth
2 *	E* psh, par, el	No readings of E* or greater
2 *	E* cf, psh, el, so, dth	E* paf, psh, so, dth
1	E psh, el, so E* ash, aar, cf, athi, kn, paf, par, dth, pthi	E paf, psh, so E* aar, cf, fa, par, el, dth

Av. 1.6 *

* Since the men in this test were subjected to only one exposure, the number of exposures tolerated was estimated by assuming that all the subjects who did not "break" as a result of the exposure, but had incurred an E*, would have broken on a second exposure.

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TABLE XXIII

TEST NO. 16 - "MAN BREAK" AT CT 2400 (40.0 H/1. for 60 Min.)

Date Started: 3-12-40

This test is the same as reported in Appendix II, Test No. 5.

TABLE XXIV

TEST NO. 17 - "MAN BREAK" AT CT 4800 (40.0 H/1. for 120 Min.)

Date Started: 3-12-45

No. of Exposures Tolerated	Readings (Hours After Last Exposure)	
	24	48
5	E ol E° psh, sc, dth, pthi, pop, ple	NV ol, ale, ple E ol, umar E° psh, sc, dth, pthi, pop, ple
3	E paf, psh, sc, dth E° umar, of, athi, kn, ale, pthi, pop, ple	E of, paf, psh, sc, dth E° ash, aar, ax, lth, kn
4	E athi, kn, ale, psh, sc, pop, ple E° el, dth	E of, athi, kn, ale, psh, sc, dth, pop, ple E° ash, el
4	E psh, sc, dth E° ash, ax, lth, athi, kn, C ₇	E psh, sc, dth

Av. 4.0

TABLE XXV

TEST NO. 18 - SINGLE EXPOSURE AT CT 9600 (40 R/H/1. for 240 Min.)

Date Started: 3-17-45

No. of Exposures Tolerated	Readings (Hours After Exposure)	
	24	48
2 *	'E° kn,el	'E° kn
2 *	'E° ash,kn,psh,sc	'E° kn,psh,sc,dth
2+*	'No readings of 'E° or greater.	'No readings of E° or greater.
2 *	'E° psh,sc,dth	'No readings of E° or greater.
2 *	'E° kn,psh,el,sc, dth	'E° kn,psh,el,sc,dth
2 *	'E° psh,sc,dth	'E° ash,psh,sc,dth
2 *	'E° umar,cf,psh,sc, dth	'E° psh,sc,dth

Av. 2.0+*

* Since the men in this test were subjected to only one exposure, the number of exposures tolerated was estimated by assuming that all the subjects who did not "break" as a result of the exposure, but had incurred an E°, would have broken on a second exposure.

TABLE XXVI

EFFECT OF TIME OF EXPOSURE - BREAKS/DAY

Date Started	No. of Men	Conc. H (%/l.)	Time of Exp. (Min.)	CT of Exp.	No. of Men Broken on Day No.													Av. Exp. No. of Hrs. Exp. Tolerated Breaks	Total	
					1	2	3	4	5	6	7	8	9	10	11	12	13			
3-2-45	8	10	60	600															5.3	5.3
3-2-45	5	10	120	1200															5.6	11.2
3-1-45	7	10	240	2400	2	5													1.7*	6.8*
Various	114	20	60	1200	8	27	23	20	6	4	3					1			4.5	4.5
3-12-45	6	20	120	2400															3.5	7.0
3-11-45	7	20	240	4800	3	4*	3	3											1.6*	6.4*
3-12-45	6	40	60	2400															4.5	4.5
3-12-45	4	40	120	4800															4.0	8.0
3-17-45	7	40	240	9600															2.0*	8.0

*Since the men in these tests were subjected to only one exposure, the number of exposures tolerated was estimated by assuming that all subjects who did not "break" as a result of the exposure, but had incurred an E, would have broken on a second exposure.

- Not "Broken"

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EFFECT OF CONCENTRATION OF VAPOR ON STANDARD "MAN BREAK"

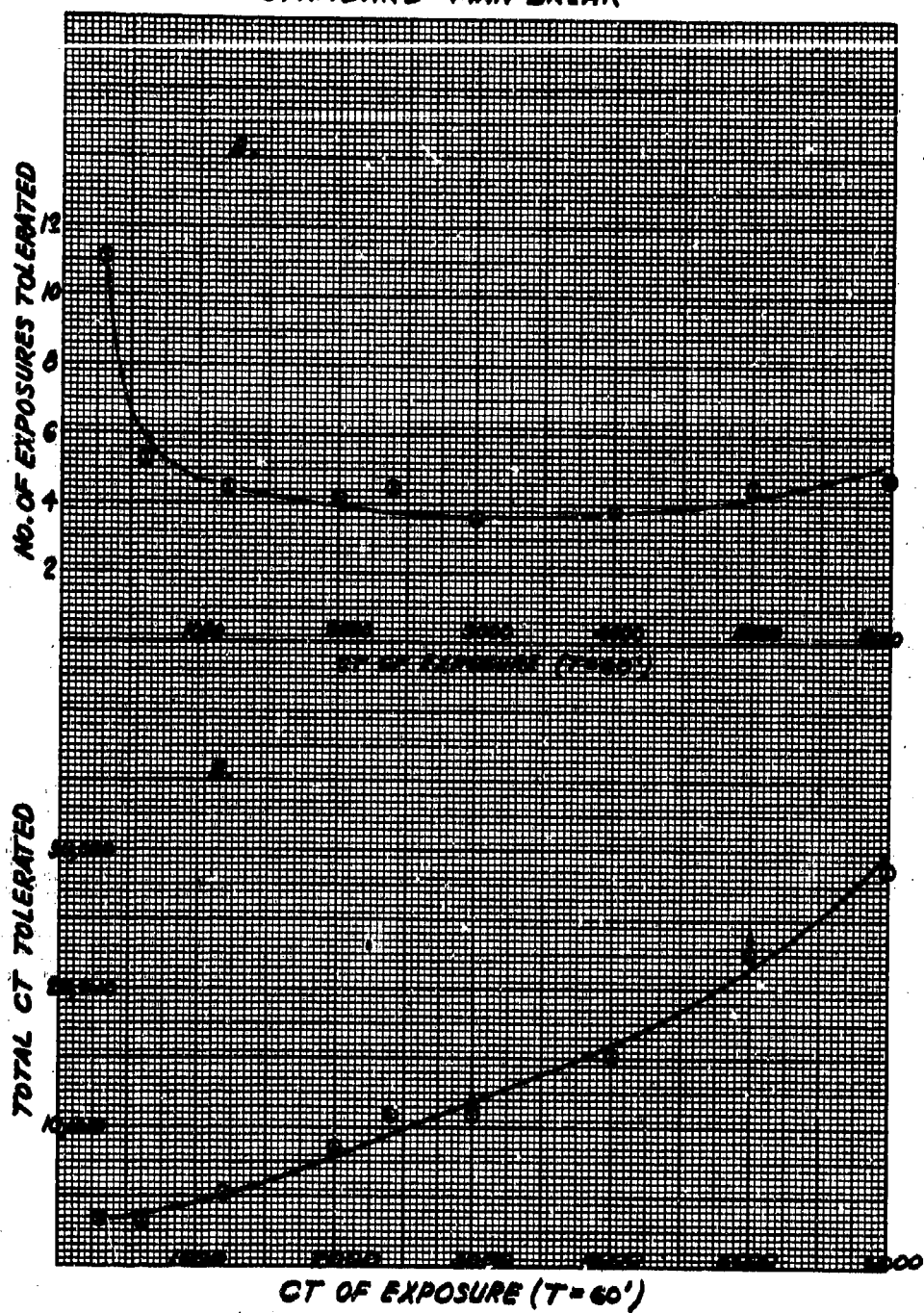


PLATE 1

JAN 1950

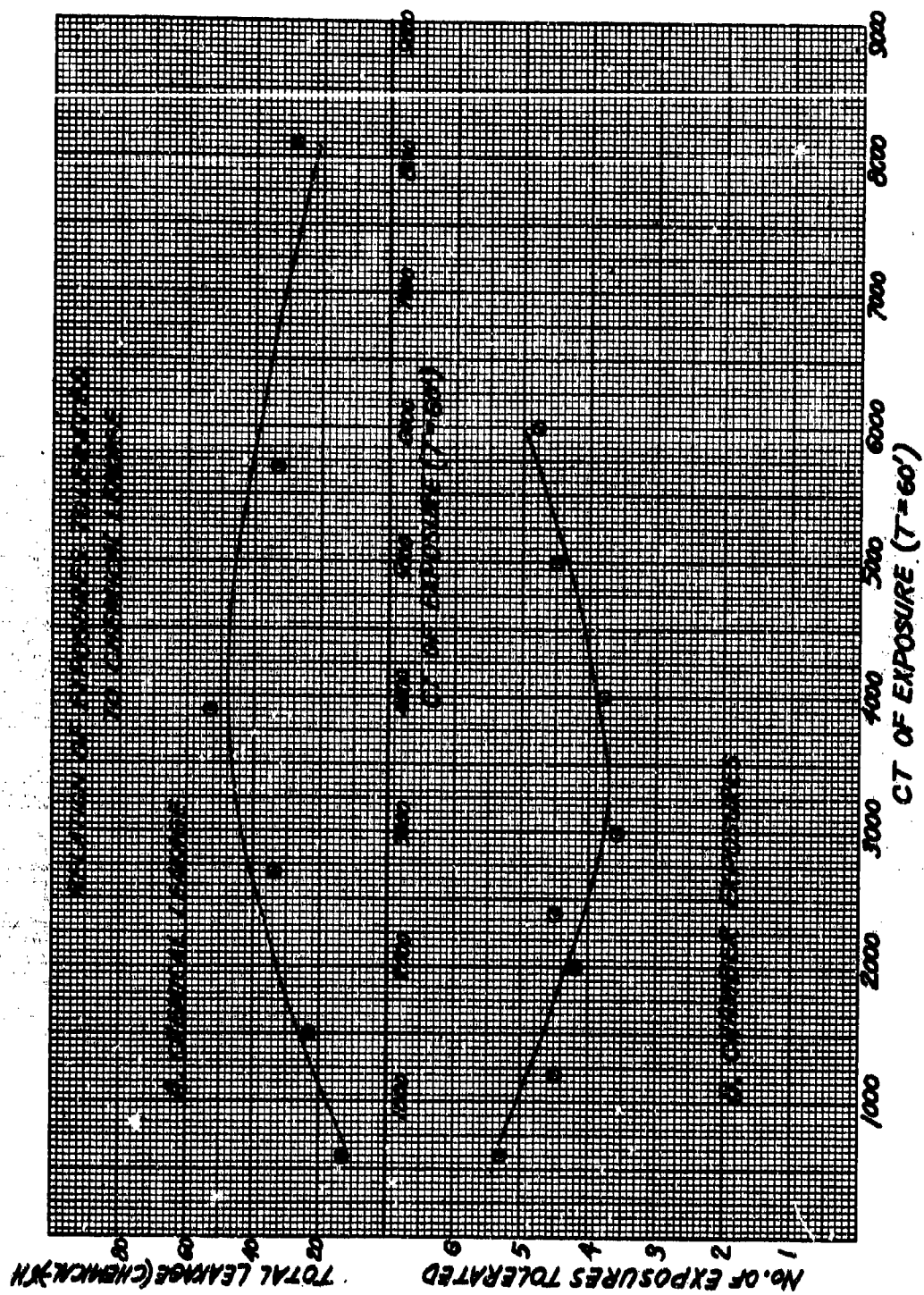


PLATE 2

